Palaeoskapha sichuanensis gen. et sp. nov. (Menispermaceae) from the Eocene Relu Formation in western Sichuan, West China

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Abstract   *Palaeoskapha sichuanensis* gen. et sp. nov. of Menispermaceae is described here for the first time based on a well preserved fossil fruit. The specimen was found in the Relu Formation of western Sichuan, West China. The specimen, straight, boat-shaped endocarp with large ventral condyle, clearly belongs to the tribe Tinosporeae. The wide aperture of the double condyle, combined with a whole shape not deeply invaginated, indicates a genus different from what was already known to science for this tribe. This fossil widens the distribution of the tribe during Eocene from North America and Europe to Asia, where it was formerly unknown.

Key words   Eocene, Menispermaceae, *Palaeoskapha sichuanensis* sp. nov., Relu Formation, Sichuan.

Modern Menispermaceae (i.e. Moonseed family) consist of approximately 70 genera and 450 species, distributed in tropical lowland regions (Kessler, 1993). They are usually twining vines, whose fruits are one-seeded drupes with taxonomically useful endocarp (Thanikaimoni, 1986).

Only a few occurrences of Menispermaceae are known in the Cenozoic of Asia (except India): *Menispermoxylon circumvallum* Vozenin-Serra & Privé-Gill, 1989, a fossil wood from Thailand (Miocene), *Entoneuron melastomaceum* Geyler, 1878, fossil leaf from Borneo (Eocene), *Cocculus flabella* (Newb.) Wolfe, 1966 fossil leaves (Guo et al., 1984) from Xinjiang, Northwest China (Palaeocene), some leaves lacking specific identification, as *Cocculus* sp. from Japan (Oligocene, Tanai, 1972; and Miocene, Ozaki, 1991), *Menispermum* sp. from Miocene of Japan (Tanai & Suzuki, 1963), *Stephania* sp. from Pliocene of Japan (Tanai, 1972). Other occurences are proposed but could not be checked: from the Oligocene of Japan (Tanai, 1970), from the Palaeocene of Jiayin, Heilongjiang, Huanqu of Shanxi, the Miocene Chifeng of Nei Mongol (Tao, 2000). The identification of fossil leaves to Menispermaceae is often doubtful, and the leaves formerly assigned to *Cocculus* have been associated with the extinct Trochodendraceous genus *Nordenskioldia* (Crane et al., 1991; Manchester et al., 1991). Therefore every discovery of new fossils confirming the Cenozoic record of the family in Asia is important. Fruits provide some of the most useful characters for identification of Menispermaceae in the fossil record (Reid & Chandler, 1933; Thanikaimoni, 1986; Jacques & De Franceschi, 2005). The recent recognition of *Diploclisia* and *Palaeosinomenium* endocarps from the Huadian coal mine in Jilin Province, Northeast China (Manchester et al., 2005) confirms the presence of Menispermaceae, tribe Menispermeae in the Middle Eocene of northeastern China. In this paper we recognize a new occurrence of the

Menispermaceae, based on a fossil fruit from the Eocene Relu Formation at Relu village in Litang County of western Sichuan Plateau, West China. It is assigned to a new genus and is significant as a member of the tribe Tinosporeae.

1   Material and methods

Two fossil fruits are collected from the Relu Formation which is situated at Relu village in Maiwa Town (ca. 30° N, 100°32′ E) in Litang County of western Sichuan Plateau, western China. The strata are 1477 m in total thickness. The field outcrop section of the Relu Formation is represented in Fig. 1.

Formerly, the geological age of the Relu Formation, based only on the stratigraphic sequence, was considered to be roughly Eocene. Based on more recent geological surveys, outcrop measurement and collection of fossil plants, the Relu Formation is primarily considered Eocene. The Eocene assignment is supported by the composition of the fossil flora, which is preserved in bed 8th grayish-brown felsic sandstone. The leaf impressions include *Chamaecyparis* sp., *Myrica* sp., *Palibinia laxifolia*, *Rhus turcomanica*, *Arundo* sp. which are shared with the Eocene Er-Oilan-Du3 fossil plant assemblage in Turkmenistan (Vasilevskaya, 1957). The extinct *Palibinia* fossils (second in abundance only to *Myrtophyllum*) are restricted to the Eocene strata in Central China, Middle Asia and South Europe, although they extend to the early Oligocene in Germany and Austria. *Trapa paulula* was found from the Palaeocene Upper Fort Union formation in North America (Brown, 1962). Therefore, the flora from the Relu Formation is concluded to represent Eocene epoch in geological age, and probably Early or Middle Eocene (GUO Shuang-Xing, unpublished manuscript).

The specimen studied has two halves: one with the impression of the ventral face, and one with the locule cast seen from ventral face and still adherent to the dorsal face.
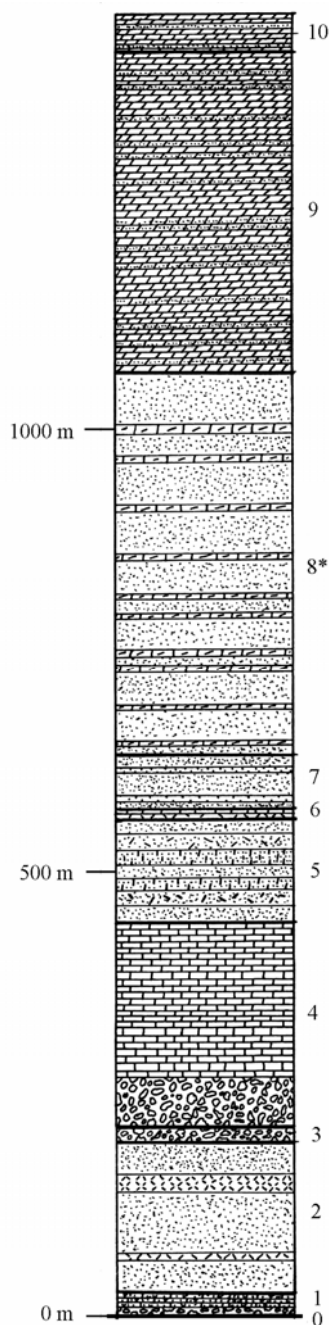

Fig. 1.   Section of the Relu Formation.   10, purple-greyish muddy dolomite intercalated felsic sandstone folium, denuded at top bed; 9, interchanging beds of greyish muddy dolomite and light purple-greyish dolomitic mudstone; 8, unequally interchanging beds of purple-greyish and greyish-brown felsic sandstone intercalated yellow dolomitic limestone, yielding fossil plants; 7, Unequally interchanging beds of purple-greyish felsic sandstone and siltstone; 6, light purple-greyish calcspar and acid tuff; 5, unequally interchanged beds of reddish sandstone, clastic sandstone and calcareous sandstone; 4, purple-reddish muddy limestone at middle and upper part, purple-reddish conglomerate at the bottom; 3, grey-green thick conglomeratic bed with andesite gravels; 2, brown-purple felsic sandstone with gravels intercalate purple-grey tuff, yielding stoneworts; 1, purple-red sandy limestone intercalated with gypsum folium at middle and upper part, conglomerate at lower part. 0, unconformity, underlying strata: Upper Triassic. * Fossil position.

The correct interpretation of the fossil therefore needs a reconstruction of its shape using these two halves.

2   Results

Palaeoskapha Jacques & Guo, gen. nov.

Type species: *Palaeoskapha sichuanensis* Jacques & Guo, sp. nov.

Etymology: *Palaios* (Old Greek = ancient) and *Skaphe* (Old Greek = boat), referring to the general shape of the endocarp.

Palaeoskapha sichuanensis Jacques & Guo, sp. nov.   Fig. 2: A, B

Syntypes: *PB12703* (endocarp) and *PB12702* (locule cast).

Repository: Nanjing Institute of Geology and Palaeontology (NIGPAS), the Chinese Academy of Sciences, China.

Type locality: Relu village (Litang, Sichuan, China).

Stratigraphic horizon: The bed 8th grayish-brown felsic sandstone of the Relu Formation (Eocene).

Description: Endocarp more or less boat-shaped, elliptic in dorsiventral outline, bisymmetric, with a sharp ventral median ridge; base rounded and apex slightly pointed, the median ridge disappearing before the base and apex a lateral wing inferred on each side; large intrusive condyle on ventral face, separated in two parts by the median ridge, with an elliptic aperture as broad as the condyle, delimited by a sharp edge; surface smooth, without any spines; length 8.5 mm, width 4.8 mm; condyle length 4.0 mm, width 3.3 mm. Locule cast bisymmetric, with a smooth ventral median ridge; base rounded and apex pointed; large intrusive condyle; surface smooth; length 6.0 mm, width 4.0 mm; condyle length 4.0 mm, width 3.3 mm.

3   Discussion

This fossil was already studied by one of us in an unpublished work (Guo, 1986, unpublished MS, p. 67, pl. 18, figs. 7, 8) under the name *Carpites bivalves*.

Many modern Tinosporeae have spiny projections on the endocarp, as in *Parabaena* Miers, but these seem to be lacking in the fossil, as indicated by the absence of any spines on the margin of the dorsal face. So, we infer and propose that the dorsal surface was smooth. However, as the locule cast recovers the dorsal surface, this character has not been seen for the whole surface. The carbonaceous part still visible on the ventral impression is relatively thin. This indicates that the endocarp wall could have been thin. The margin of the ventral impression is larger than the locule cast of the seed cavity. It seems to us that this margin could not represent only the seed cavity, but is the sign of another structure. As the endocarp wall is thin, it could not have left such an important mark. The presence of a lateral wing, which is a usual character in the tribe Tinosporeae to which belongs *Palaeoskapha*, can well explain this large margin. In modern Tinosporeae, there is no species with a winged endocarp lacking ventral protruding chamber. Then *Palaeoskapha* represents a transition form between two types of endocarp: those having wings and ventral protruding chamber, and those lacking both.

The boat-shaped endocarp and locule cast, with straight, rather than longitudinally curved, profile of the species clearly indicates that it belongs to the tribe Tinosporeae Hook. f. & Thoms. This tribe includes about 19 genera that are distributed today in North and South America, Africa and Asia. The large and widely open condyle of this fossil is similar to that of *Calycocarpum* Nutt. ex Torr. & Gray and *Jateorhiza* Miers (Fig. 3). However it cannot be placed into one of these genera: *Jateorhiza* has a flange that slightly overlaps the condyle;
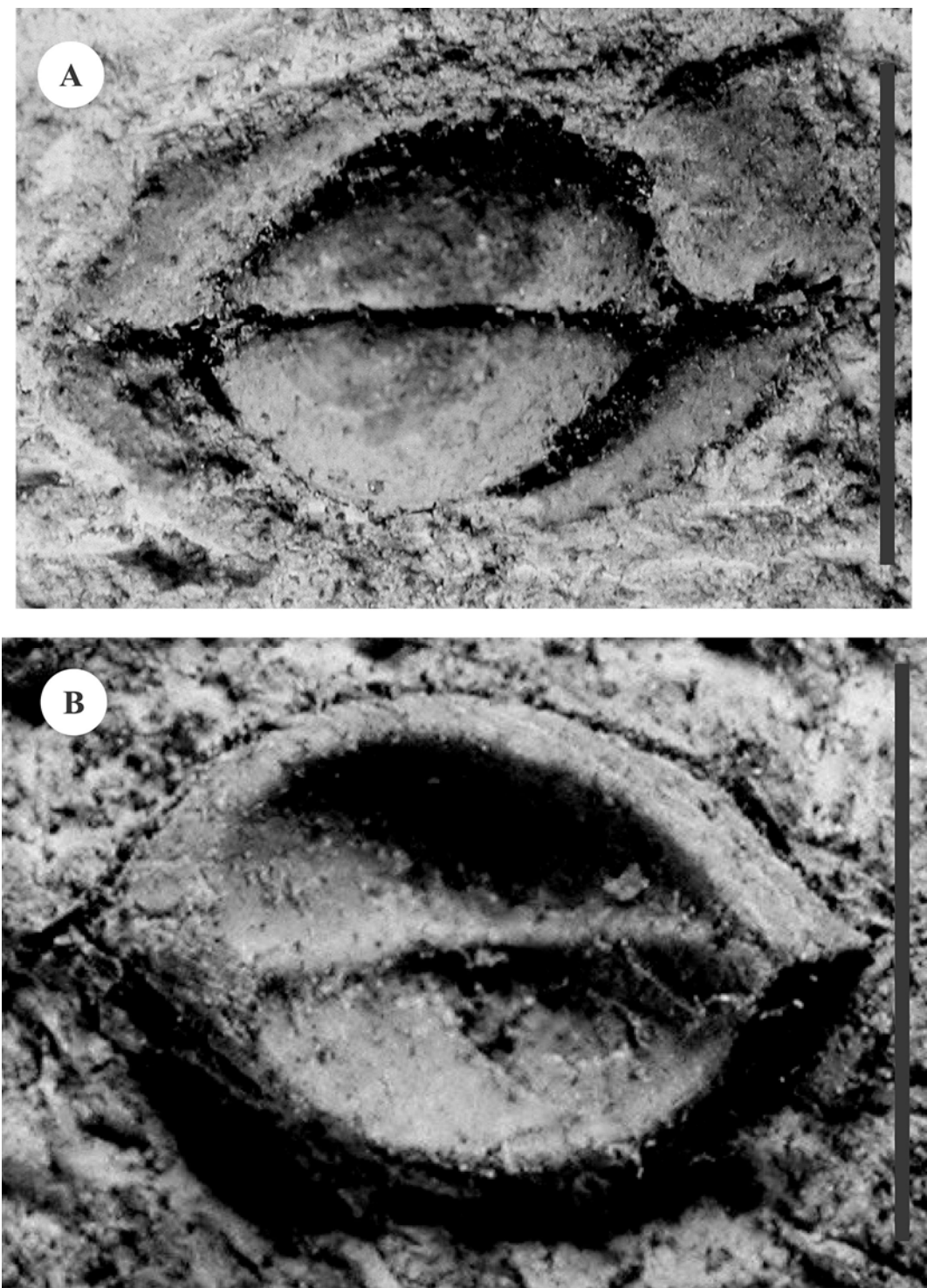
Fig. 2.   A. Endocarp of *Palaeoskapha sichuanensis* sp. nov. (*PB12703*). **B.** Locule cast of *Palaeoskapha sichuanensis* sp. nov. (*PB 12702*). Scale bar = 5 mm.

Calycocarpum is more invaginated, being hemispherical; neither of them is winged. The lateral wings interpreted for *Palaeoskapha* suggest affinities to winged genera of Tinosporeae, such as *Chasmanthera* Hochst. or *Leptoterantha* J. Louis ex Troupin, but they have a condyle developed in protruding ventral chamber (Fig. 3). The chamber of *Kolobopetalum ovatum* Stapf is the least closed species, but is not totally open. Those reasons justify the placement of this species in a new genus.
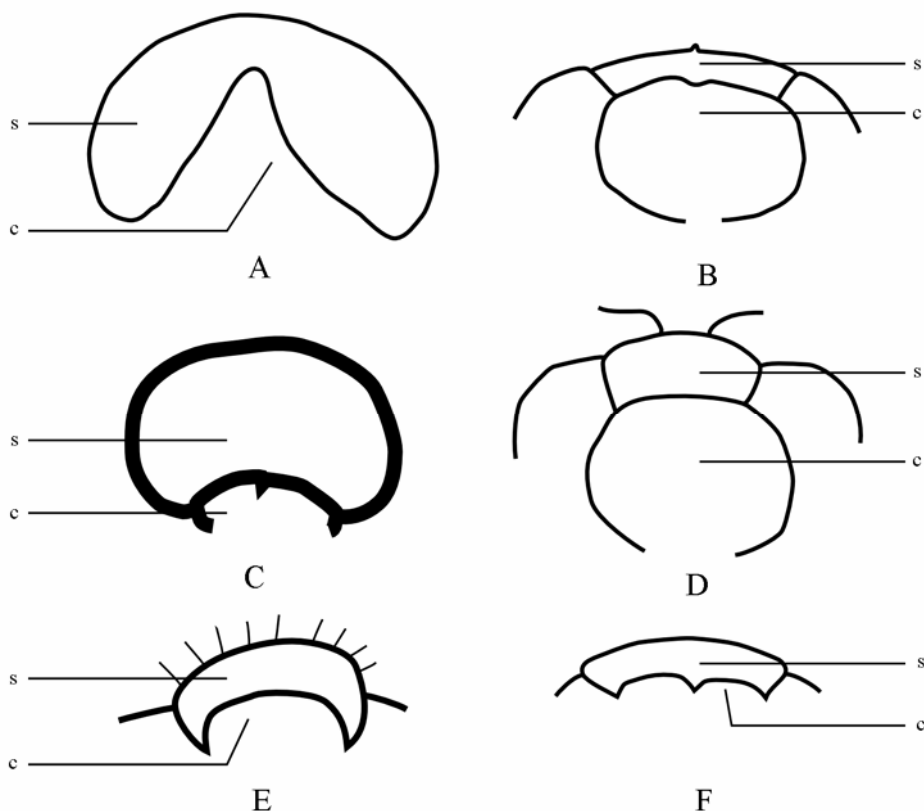

Fig. 3. Comparison of the transversal section of endocarps of the tribe Tinosporeae and *Palaeoskapha sichuanensis* sp. nov. s, seed cavity; c, condyle. **A.** *Calycocarpum lyonii* (Nutt.) Gray. **B.** *Chasmanthera dependens* Hochst. **C.** *Jateorhiza macrantha* (Hook. f.) Exell & Mendonca. **D.** *Leptoterantha mayumbensis* (Exell) Troupin. **E.** *Kolobopetalum ovatum* Stapf. **F.** *Palaeoskapha sichuanensis* sp. nov.

The specimen underwent a small geological deformation: a slight shift parallel to the plane of symmetry. Both valves are thus not completely face to face any more.

Although the *Palaeoskapha sichuanensis* fossil is found in western China, *Jateorhiza*, *Chasmanthera*, *Kolobopetalum* Engl., *Leptoterantha* are from Africa whereas *Calycocarpum* is a North-American genus. The extant Asian Tinosporeae, including *Tinospora*, *Parabaena*, *Aspidocarya* and *Chlaenandra* are readily distinguished in fruit morphology from *Palaeoskapha* because they all lack such a widely aperturate condyle. However, usually European and North-American Eocene Menispermaceae have Asian affinities (Reid & Chandler, 1933; Manchester, 1994; Jacques & De Franceschi, 2005). The distributions of all genera with affinities to *Palaeoskapha sichuanensis* are summarized in Table 1.

Table 1   Distribution of modern (M) and fossil (F) species of genera with affinites to *Palaeoskapha sichuanensis*

	Africa	North America	Asia	Europe
Aspidocarya			M	
Calycocarpum		M, F		F
Chasmanthera	M			
Chlaenandra			M	
Jateorhiza	M			F
Kolobopetalum	M			
Leptoterantha	M			
Parabaena			M	
Tinospora	M	F	M	F

Thanikaimoni (1986) proposed that Menispermaceae could originate from Africa, and only later colonized Asia via India, is difficult to keep, considering the early presence of diverged species in Eocene of China. A better knowledge of Menispermaceae fossils from Asia will allow a better understanding of their biogeographical implications.

Other species found along with *Palaeoskapha sichuanensis* give good clues to the palaeoecology of the site. The fossil plants from the Relu Formation contain 18 taxa (including five new species) belonging to 17 genera of 11 families. The fossil taxa include *Chamaecyparis* (Cupressaceae); *Trapa paulula* (Bell) Brown (Trapaceae); *Syzygium* sp., *Myrtophyllum* (two species) (Myrtaceae); *Sorbus* sp. (Rosaceae); *Leguminocarpon* sp. (Leguminosae); *Myrica* sp., *Palibinia laxifolia* Korovin (Myricaceae); *Ulmus* sp., *Zelkova ungeri* Kovats. (Ulmaceae); *Evodia* sp., *Rutaphyllum* (Rutaceae); *Rhus turcomanica* (Krysht.) Korovin (Anacardiaceae); *Cyperacites* sp. (Cyperaceae); *Arundo* sp. (Gramineae). Besides these this flora includes two formerly unclassifiable taxa, namely *Carpites* and *Antholithes* spp. Among the fossil plants, the form genera *Myrtophyllum* and *Palibinia* are most abundant, occupying 73% of the total. The evergreen and deciduous plants are nearly equal in number of species; however, the evergreen plants are greater in abundance than the deciduous ones. Accordingly, the fossil plants are considered to represent an evergreen broad-leaved forest.

4   Conclusion

Palaeoskapha sichuanensis represents a confirmed occurence of Menispermaceae fossil fruits from the Cenozoic (Eocene) of China. It represents also the only occurence of the tribe Tinosporeae, however widely present in Asia nowadays. Therefore, this carpological fossil of Menispermaceae in Asia raises new questions concerning palaeobiogeography of this family. The fossil shows an interesting combination of characters (a widely opened condyle associated with a slightly pointed apex) which is not found in modern Menispermaceae. The palaeobotanical research in Asia could provide new perspectives for our understanding of Menispermaceae family.

References

Brown R W. 1962. Paleocene floras of the Rocky Mountains and great Plains. U.S. Geological Survey Professional Paper 375: 1–119, 69 pls.

Crane P R, Manchester S R, Dilcher D L. 1991. Reproductive and vegetative structure of *Nordenskioldia* (Trochodendraceae) a vesselless dicotyledon from the Tertiary of the Northern Hemisphere. American

Journal of Botany 78: 1311–1334.

Geyler H T. 1878. Ueber Fossile Pflanzen von Borneo. Paleontographica Supplement 3 (2): 59–91.

Guo S-X. 1986. Floral character of Eocene Relu Formation and history of *Eucalyptus* from Litang of Sichuan. Exploration of Hengduan Mountain area (II). Beijing: Beijing Publishing House of Sciences and Technology. 69–73. (in Chinese and English summary)

Guo S-X, Sun Z-H, Li H-M, Dou Y-W. 1984. Paleocene megafossil flora from Altai of Xinjiang. Bulletin of Nanjing Institute of Geolology & Palaeontology, Academia Sinica 8: 119–146, 8 pls.

Jacques F M B, De Franceschi D. 2005. Endocarps of Menispermaceae from Le Quesnoy outcrop (Sparnacian facies, Lower Eocene, Paris Basin). Review of Palaeobotany and Palynology 135: 61–70.

Kessler P J A. 1993. Menispermaceae. In: Kubitzki K, Rhower J G, Bittrich V eds. The Families and Genera of Vascular Plants. Berlin: Springer. 2: 402–418.

Manchester S R. 1994. Fruits and Seeds of Middle Eocene Nut Beds Flora, Clarno Formation Oregon. Palaeontographica Americana 58: 1–205.

Manchester S R, Chen Z-D, Geng B-Y, Tao J-R. 2005. Middle Eocene flora of Huadian, Jilin Province, Northeastern China. Acta Paleobotanica 45 (1): 3–26.

Manchester S R, Crane P R, Dilcher D L. 1991. *Nordenskioldia* and *Trochodendron* (Trochodendraceae) from the Miocene of Northwestern North America. Botanical Gazette 152: 357–368.

Ozaki K. 1991. Late Miocene and Pliocene Floras in Central Honshu, Japan. Bulletin of Kanagawa Prefectural Museum, Natural Sciences, Special Issue: 1–244.

Reid E M, Chandler M E J. 1933. The London Clay. London: The British Museum (Natural History).

Tanai T. 1970. The Oligocene floras from the Kushiro coal field, Hokkaido, Japan. Journal of the Faculty of Science, Hokkaido University, Series 4: Geology and Mineralogy 14: 383–514.

Tanai T. 1972. Tertiary History of Vegetation in Japan. In: Graham A ed. Floristics and Paleofloristics of Asia and Eastern North America. Amsterdam: Elsevier Publising Company. 235–255.

Tanai T, Suzuki N. 1963. Miocene Floras of Southwestern Hokkaido, Japan. In: Tanai T, Suzuki N eds. Tertiary Floras of Japan, Miocene Floras. The collaborating association to commemorate the 80th anniversary of the geological survey of Japan. 7–149.

Tao J-R. 2000. The Evolution of the Late Cretaceous-Cenozoic Floras in China. Beijing: Science Press. 1–282.

Thanikaimoni G. 1986. Evolution of Menispermaceae. Canadian Journal of Botany 64: 3130–3133.

Vasilevskaya N D. 1957. Eotzenovaya flora Badhyza v Turkumenii. Sbor. Pamyati AN Kryshtofovich: stp. 103–175. Tabl. 1–7, Ezd. AN SSSR, M.-L. (in Russian)

Vozenin-Serra C, Privé-Gill C, Ginsburg L. 1989. Bois miocènes du gisement de Pong, Nord-Ouest de la Thaïlande. Review of Palaeobotany and Palynology 58: 333–355.

Wolfe J A. 1966. Tertiary plants from the Cook Inlet Region Alaska. U.S. Geological Survey Professional Paper 398B: 1–32, 8 pls.